Given \( \frac{b+c}{a} = \frac{c+a}{b} = \frac{a+b}{c} \) for a \( \triangle ABC \) with usual notation. If \( \frac{\cos A}{\alpha} = \frac{\cos B}{\beta} = \frac{\cos C}{\gamma} \), then the ordered triplet \((\alpha, \beta, \gamma)\) has a value:

\( \frac{b+c}{11} = \frac{c+a}{12} = \frac{a+b}{13} \)

\( \cos A = \frac{36k^2 + 25k^2 - 49k^2}{2(6k)(5k)} = \frac{19}{35} \)

\( \cos B = \frac{49k^2 + 25k^2 - 29k^2}{2(7k)(5k)} \)

and \( \cos C \) can be calculated.

From the calculation, the possible ordered pair is \((7, 19, 25)\)
2. The integral \( \int_{0}^{\frac{\pi}{6}} \frac{dx}{\sin 2x (\tan^2 x + \cot^2 x)} \) equals:

\[
\int_{\frac{\pi}{6}}^{\frac{\pi}{3}} \frac{dx}{\sin 2x (\tan^2 x + \cot^2 x)}
\]

\( \text{Ans.} \quad 4 \)

\( \text{Sol.} \quad \int_{\frac{\pi}{6}}^{\frac{\pi}{3}} \frac{dx}{\sec^2 x} \)

---

3. A bag contains 30 white balls and 10 red balls. 16 balls are drawn one by one randomly from the bag with replacement. If \( X \) be the number of white balls drawn then Mean of \( X \) is equal to standard deviation of \( X \) is equal to

\( \text{Mean of } (X) = \frac{30}{30} \cdot 16 = \frac{16}{16} \)

\( \text{Standard deviation of } (X) = \frac{\sqrt{30}}{\sqrt{16}} \cdot 16 = \frac{\sqrt{30}}{4} \cdot 16 \)

\( \text{Ans.} \quad (4) \)

\( \text{Sol.} \quad \text{There are 30 white balls and 10 red balls} \)

\( \text{30} \) \( \text{white balls} \) \( \text{and} \) \( 10 \) \( \text{red balls} \)

\( P(\text{white ball}) = \frac{30}{40} = \frac{3}{4} \)

\( P(\text{red ball}) = \frac{10}{40} = \frac{1}{4} \)

\( \text{mean} (X) = \frac{30}{40} \cdot 16 = 12 \)

\( \text{standard deviation} (X) = \sqrt{\frac{30}{40} \cdot 16} = \frac{\sqrt{30}}{4} \cdot 16 \)

---

4. If the area of the triangle whose one vertex is at the vertex of the parabola, \( y^2 = 4(x - a)^2 = 0 \) and the other two vertices are the points of intersection of the parabola and y-axis, is 250 sq. units, then a value of 'a' is

\( y^2 = 4(x - a)^2 \)

\( \text{Ans.} \quad (3) \)

\( \text{Sol.} \quad y^2 = -4(x - a)^2 \)

For B and B' put x = 0 in parabola

---
5. A circle cuts the chord of length $4a$ on $x$-axis and passes through a point on the $y$-axis, distant $2b$ from the origin. Then the locus of the centre of this circle, is:

- A parabola
- A hyperbola
- An ellipse
- A straight line

(1) a parabola (2) a hyperbola (3) an ellipse (4) a straight line

Ans. (1)

6. Let $z$ be a complex number such that $|z| + z = 3 + i$, (where $i = \sqrt{-1}$) then $|z|$ is equal to:

- $\frac{\sqrt{34}}{3}$
- $5/4$
- $5/3$
- $\frac{\sqrt{41}}{4}$

Ans. (3)

7. Let $S_q = 1 + q + q^2 + \ldots + q^r$ and $T_q = 1 + \left(\frac{q+1}{2}\right)^2 + \ldots + \left(\frac{q+1}{2}\right)^r$.

where $q$ is a real number and $q \neq 1$. If $101C_1 + 101C_2 + \ldots + 101C_{100} = \alpha T_{100}$ then $\alpha$ is equal to

(1) $200$
(2) $2^{100}$
(3) $3^{100}$
(4) $2^{202}$

Ans. (3)
\[
\sum_{r=1}^{10} C_{101-r} = \sum_{r=1}^{10} C_{91-r} - \frac{1}{q-1} \left( \sum_{r=1}^{10} C_{q-r} - \sum_{r=1}^{10} C_{r} \right) = \frac{1}{q-1} \left( (1+q)^{101} - 1 - 2(101) \right)
\]

\[
\Rightarrow \quad a \left( \frac{q+1}{2} \right)_{101} - 1 = \frac{1}{q-1} \left( (1+q)^{101} - 2(101) \right)
\]

\[
\Rightarrow \quad \frac{2^{100}}{1} \left( \frac{(1+q)^{101} - 2}{q-1} \right) = \frac{1}{q-1} \left( (1+q)^{101} - 2\right)
\]

\[
\Rightarrow \quad \text{Hence we get: } a = 2^{100}
\]

8. If \[ \begin{vmatrix}
2a & 2a & 2a \\
2b & b - c - a & 2b \\
2c & 2c & c - a - b
\end{vmatrix} = (a + b + c) (x + a + b + c)^2, \quad x \neq 0 \quad \text{and} \quad a + b + c \neq 0, \quad \text{then } x \text{ is equal to}
\]

\[
\begin{align*}
\text{(1) } abc & \quad (2) (a + b + c) \\
\text{(3) } -(a + b + c) & \quad (4) -2(a + b + c)
\end{align*}
\]

\[\text{Ans. } (4)\]

\[\text{Sol. } R_1 \rightarrow R_1 + R_2 + R_3, (a + b + c) \begin{vmatrix}
1 & 1 & 1 \\
2b & b - c - a & 2b \\
2c & 2c & c - a - b
\end{vmatrix} = 0
\]

9. If a hyperbola has length of its conjugate axis equal to 5 and the distance between its foci is 13, then eccentricity of the hyperbola is:

\[
\text{यदि एक अवध्यक्ष का सांरक्षणीय रेखा 5 है तथा इसके केनों के दूरी 13 है, तो इस अवध्यक्ष का उद्देश्य है:}
\]

\[\begin{align*}
\text{(1) } \frac{13}{6} & \quad (2) \frac{13}{12} \\
\text{(3) } 2 & \quad (4) \frac{13}{8}
\end{align*}\]

\[\text{Ans. } (2)\]

\[\text{Sol. } b = \frac{5}{2}, a = \frac{13}{2}, (aa)^2 = \frac{169}{4} \Rightarrow a^2 + b^2 = 169\]

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\[a^2 = \frac{169}{4}, b^2 = \frac{25}{4}, c^2 = 144 \Rightarrow a = \frac{13}{2}, b = 6\]

\[\text{Hence } \frac{c}{a} = \frac{12}{13} = \frac{12}{12}\]

10. If \[ \int \frac{(x+1)}{\sqrt{2x-1}} \, dx = f(x) \sqrt{2x-1} + C, \quad \text{where } C \text{ is a constant of integration, then } f(x) \text{ is equal to}
\]

\[
\begin{align*}
\text{(1) } \frac{2}{x + 2} & \quad (2) \frac{2}{3} (x - 4) \\
\text{(3) } \frac{1}{3} (x + 4) & \quad (4) \frac{1}{3} (x + 1)
\end{align*}
\]

\[\text{Ans. } (3)\]

\[\text{Sol. } p = (2x - 1) = \frac{d}{dx} \text{, hence } df = dx \Rightarrow 2dx = dt \text{, so } dt = dx = 1\, dt
\]

\[\int \frac{(x+1)}{\sqrt{2x-1}} \, dt = \int \frac{(x+1)}{2} \, dt = \frac{1}{2} \left( x^2 + 4x + 9 \right) + C = \frac{1}{2} (2x - 1)^{3/2} + C
\]
11. Let the length of the latus rectum of an ellipse with its major axis along x-axis and centre at the origin, be 8. If the distance between the foci of this ellipse is equal to the length of its minor axis, then which one of the following points lies on it?

\[ \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \]

Given:
- \( a = 4 \) (since the length of the latus rectum is 8)
- \( \sqrt{a^2 - b^2} = 2 \) (distance between the foci is equal to the length of the minor axis)

\[ 2b = 2a \Rightarrow b = \frac{1}{2} a \]

Hence, the equation of the ellipse is:
\[ \frac{x^2}{a^2} + \frac{y^2}{\frac{1}{4}a^2} = 1 \]

The correct option is (4).

12. If 16th term of a non-zero A.P. is zero, then its (48th term) : (29th term) is:

\[ a + 18d = 0 \Rightarrow a = -18d \]

\[ \frac{t_{48}}{t_{29}} = \frac{a + 47d}{a + 28d} = \frac{30d}{10d} = 3 \]

The correct option is (3).

13. The number of functions \( f \) from \( \{1, 2, 3, \ldots, 20\} \) onto \( \{1, 2, 3, \ldots, 20\} \) such that \( f(k) \) is a multiple of 3, whenever \( k \) is a multiple of 4, is:

\[ \begin{align*}
(1) & \quad 5! \times 6! \\
(2) & \quad 15! \times 6! \\
(3) & \quad 6! \times 15! \\
(4) & \quad 5! \times 15!
\end{align*} \]

The correct option is (2).

14. Let \( S = \{1, 2, \ldots, 20\} \). A subset \( B \) of \( S \) is said to be "nice" if the sum of the elements of \( B \) is 203. Then the probability that a randomly chosen subset of \( S \) is "nice" is:

\[ \begin{align*}
(1) & \quad \frac{4}{2^{20}} \\
(2) & \quad \frac{5}{2^{20}} \\
(3) & \quad \frac{7}{2^{20}} \\
(4) & \quad \frac{6}{2^{20}}
\end{align*} \]

The correct option is (2).
15. Let \( f(x) = \frac{x}{\sqrt{a^2 + x^2}} - \frac{(d-x)}{\sqrt{b^2 + (d-x)^2}} \), where \( a, b \) and \( d \) are non-zero real constants. Then:

1. \( f \) is neither increasing nor decreasing function of \( x \)
2. \( f \) is an increasing function of \( x \)
3. \( f \) is not a continuous function of \( x \)
4. \( f \) is a decreasing function of \( x \)

---

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**| JEE MAIN-2019 | DATE: 11-01-2019 (SHIFT-2) | MATHEMATICS**

16. Let \( a \) and \( b \) be the roots of the quadratic equation \( x^2 \sin \theta - x(\sin \theta \cos \theta + 1) \cos \theta = 0 \) \((0 < \theta < 45^\circ)\), and \( a < b \). Then \( \sum_{n=0}^{\infty} \frac{(-1)^n a^n}{b^n} \) is equal to

\[
\sum_{n=0}^{\infty} \frac{(-1)^n a^n}{b^n} = \frac{\cos \theta + \sin \theta}{2\sin \theta} = \frac{1}{\sin \theta} - \frac{1}{\cos \theta}
\]

---

17. Contrapositive of the statement "If two numbers are not equal, then their squares are not equal" is:

1. If the squares of two numbers are not equal, then the numbers are not equal
2. If the squares of two numbers are not equal, then the numbers are equal
3. If the squares of two numbers are equal, then the numbers are equal
4. If the squares of two numbers are equal, then the numbers are not equal
(3) Contrapositive of \( p \rightarrow q \) statement is \( \neg q \rightarrow \neg p \)
Option (3) is correct answer

\( p \rightarrow q \) का विपरीत समूच्छेद है \( \neg q \rightarrow \neg p \) है।

(4) The area (in square units) in the first quadrant bounded by the parabola, \( y = x^2 + 1 \), the tangent to it at the point (2,5) and the coordinate axes is:

\[ A = \text{area of region MBP} - \text{area of } \triangle AOB = \int \left( (x^2 + 1) - 4x - 3 \right) \, dx = \frac{3}{4}x^2 - 4x + 4 \text{ dx} - \frac{9}{8} \]
20. Let a function \( f : (0, \infty) \rightarrow (0, \infty) \) be defined by \( f(x) = \left( 1 - \frac{1}{x} \right) \), then \( f(x) \) is

(1) injective only
(2) both injective as well as surjective
(3) neither injective nor surjective
(4) not injective but it is surjective

Ans. (4)

Sol. As the domain is \((0, \infty)\), \( x = 1, f \) will not have any image if we discard the solutions is outside \((0, \infty)\), \( x = 1 \), thus, let \( f(x) \) be an injective function.

\[
f(x) = \left( 1 - \frac{1}{x} \right)
\]

many one and onto सुधारी क्वालिटी के लिए

21. Let \( A \) and \( B \) be two invertible matrices of order \( 3 \times 3 \). If \( \det(ABA^{-1}) = 8 \) and \( \det(AB^{-1}) = 8 \), then \( \det(BA^{-1}B^T) \) is equal to:

(1) 18
(2) 16
(3) 18
(4) 1

Ans. (2)

Sol. \[\begin{align*}
|AA'B| &= 8 \\
|A'B| &= 8
\end{align*}\]

So \( |A| = 1 \) because \( |AB| = 8 \) and \( |A| = 8 |B| \)

So \( |B| = \frac{8}{18} = \frac{4}{9} \)

\[\begin{align*}
|BB^{-1}| &= \frac{B^T}{|A|} = \frac{B^T}{1} = \frac{B}{8} = \frac{1}{16}
\end{align*}\]

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22. Let \( K \) be the set of all real values of \( x \) for which the function \( f(x) = \sin x - |x| + 2x - x \cos x \) is not differentiable. Then the set \( K \) is:

(1) \( \{ x : x = 0 \} \)
(2) \( \{ 0 \} \)
(3) \( \{ x : x \neq 0 \} \)
(4) \( \{ x : x \neq 0 \} \) (an empty set)

Ans. (4)

Sol. Only checking point of non-differentiability is \( x = 0 \).

Checking at \( x = 0 \) we get:

\[
f(x) = \sin x - x + 2(x - x) \cos x
\]

\[
f(x) = -x + 2(x - x) \cos x
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\[
LHD = RHD
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\[
\text{differentiable at } x = 0 \text{ अकार्नियन } \Rightarrow \text{ differentiable everywhere} 
\]
23. Let $\sqrt{3} \mathbf{i} + \mathbf{j}$, $\mathbf{i} + \sqrt{3} \mathbf{j}$ and $\beta \mathbf{i} + (1-\beta) \mathbf{j}$ respectively be the position vectors of the points A, B and C with respect to the origin O. If the distance of C from the bisector of the acute angle between OA and OB is $\frac{3}{\sqrt{2}}$, then the sum of all possible values of $\beta$ is:

\[
\frac{|\beta-(1-\beta)|}{\sqrt{2}} = \frac{3}{\sqrt{2}}
\]

$= |2| - 1 = 3 \Rightarrow |2\beta - 1| = 3 \Rightarrow 2\beta - 1 = \pm 3 \Rightarrow \beta = 2 \text{ or } \beta = -1$

\[
\text{Sum of values of } \beta \text{ is } 1
\]

Ans. (2) (4)
Sol. Equation of angle bisector of OA and OB is $y = x$
OA and OB के बीच का माध्यमक क्र समीकरण $y = x$

24. The solution of the differential equation $\frac{dy}{dx} = (x - y)^2$, when $y(1) = 1$ is :

\[
\frac{dy}{dx} = (x - y)^2, \text{ जबकि } y(1) = 1 \Rightarrow \text{ का हल है }:
\]

(1) $\log \left| \frac{1-x+y}{1-x-y} \right| = 2(x-1)$

(2) $\log \left| \frac{2-y}{2-x} \right| = 2(y-1)$

(3) $\log \left| \frac{2-x}{2-y} \right| = x-y$

(4) $\log \left| \frac{1+x-y}{1+x+y} \right| = x+y-2$

Ans. (1)
Sol. $x - y = 1$

25. If the point $(2, \alpha, \beta)$ lies on the plane which passes through the points $(3, 4, 2)$ and $(7, 0, 6)$ and is perpendicular to the plane $2x - 5y = 15$, then $2\alpha - 3\beta$ is equal to:

(1) $7$

(2) $5$

(3) $12$

(4) $17$

Ans. (1)
Sol. $A(0, 0, b), B(3, 4, 2), C(7, 0, 6)$

Direction ratio निर्देशक:\n\[
\text{Plane } P_1 \text{ is perpendicular to plane } P_2 \text{ Hence direction cosine of normal of plane } P_2 \text{ is parallel to plane } P_1\text{, sum ratio } P_2 \text{ के समानता } P_1\text{ के समानता है}
\]
26. Let \((x + 10)^{10} + (x - 10)^{10} = a_0 + a_1x + a_2x^2 + \ldots + a_{10}x^{10}\), for all \(x \in \mathbb{R}\); then \(\frac{a_1}{a_0}\) is equal to
\[
\frac{a_1}{a_0} = \frac{100 \times 49}{4} = 2 \times 10^{10}
\]

Ans. (4)

Sol. \(a_1 = \frac{\partial}{\partial x} (x + 10)^{10} + (x - 10)^{10} = 10 \times 10^{9} + 10 \times (x - 10)^{9}\)

27. Two lines \(x - 3 = \frac{y + 1}{1} = \frac{z - 6}{-1}\) and \(x - 3 = \frac{y - 2}{2} = \frac{z - 3}{4}\) intersect at the point \(R\). The reflection of \(R\) in the \(xy\)-plane has coordinates:

\(R\) is given by \(x = 3, y = 1, z = 6\) and \(R'\) is given by \(x = 3, y = -1, z = -3\).

Ans. (3)

Sol. The point of intersection of the two lines can be found by solving the system of equations:

\[
\begin{align*}
10x + 10 &= 0 \\
10y - 20 &= 0 \\
10z - 30 &= 0
\end{align*}
\]

Hence, the point of intersection is \(P(0, 2, 3)\) and the reflection of \(P\) in the \(xy\)-plane is \(P'(0, 2, -3)\).
29. Let \( x, y \) be positive real numbers and \( m, n \) positive integers. The maximum value of the expression
\[
\frac{x^m y^n}{(1 + x^m)(1 + y^n)}
\]
is:

\[\text{Ans.} \quad 4\]

\[\text{Sol.} \quad \frac{x^m y^n}{(1 + x^m)(1 + y^n)}
\]
Divide by \( x^m y^n \) to get,
\[
\frac{1}{x + \frac{1}{y}}
\]
\[
\frac{1}{x^m + x^n} \geq 2, \quad \frac{1}{y^m + y^n} \geq 2
\]
There by maximum value of \( \frac{x^m y^n}{(1 + x^m)(1 + y^n)} \) is \( 2 \times 2 \)

30. If in a parallelogram \( ABCD \), the coordinates of \( A, B \) and \( C \) are respectively \( (1, 2), (3, 4) \) and \( (2, 5) \), then the equation of the diagonal \( AD \) is:

\[\text{Ans.} \quad 1\]

\[\text{Sol.} \quad \text{Let coordinate of } D \text{ be } (x, y) \text{ so } x + 1 = 5, y + 2 = 9 \Rightarrow x = 4, y = 7
\]
\[\text{D के निर्देशांक } (x, y) \text{ है इसलिए } x + 1 = 5, y + 2 = 9 \Rightarrow x = 4, y = 7
\]
\[\text{Slope of } AD \quad \frac{2 - 5}{4 - 1} = 3
\]
\[\text{AD की लंबाई } \frac{2 - 5}{4 - 1} = 3
\]
hence equation of \( AD \) is \( 5x - 3y + 1 = 0
\]

\[\text{अन्तः } AD \text{ का समीकरण } 5x - 3y + 1 = 0
\]